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Advanced OOP and new syntax patterns for Javascript

Alessandro Rosa

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Advanced OOP and new syntax patterns for Javascript

Alessandro Rosa

January 19, 2023

Keywords – Transpiler, Javascript

Abstract

We present OBJS, a new Javascript transpiler project featuring a typified variables management, together with new syntax patterns.

Contents

1	Introduction	2
2	Disclaimer	3
3	A note about this project	3
4	New and revisited syntax patterns	4
4.1	Multiple actions	4
4.1.1	Assignments.	4
4.1.2	Comparisons.	5
4.2	Array	6
4.2.1	Special extraction.	6
4.2.2	Pushing an element once or repeatedly.	6
4.2.3	Popping one element once or repeatedly.	7
4.3	JSON structures	7
4.3.1	Compact and dynamics construction	8
4.3.2	Decorated tokens for JSON.	8
4.4	Reverse self-operators	10
4.5	The <code>ifchain</code> decisional statement	10
4.6	Extended <code>switch</code>	11
4.7	Fork operator	11
4.8	Binary operators	12
4.9	Decorated identifiers	13
4.10	Namespaces	13

5	Data typification	15
5.1	Typified declarations	15
5.2	Functions in Javascript	16
5.2.1	A short synopsis on the declaration pattern	16
5.2.2	Typified function declaration	17
5.2.3	Safe argument	20
6	Syntactic sugars	20
6.1	Block repeater	20
6.2	Ordered sequences.	20
7	Optimizations	21
7.1	Unreferenced function argument	21
7.2	Unreachable or dead code	21
7.3	Isolated deletion	22
7.4	Constant folding	22
7.5	Constant propagation	22
8	Preprocessors	22
8.1	The <code>#overload</code> directive.	22
8.1.1	Symbolic operators	23
8.1.2	Functions	24
8.1.3	Commands	25
8.1.4	Overloading the reserved: speaking in Javascript	25
8.1.5	Code event response: overloading the events	26
8.1.6	Events timeline.	26
8.1.7	Array popping and pushing.	27
8.1.8	Declaration, assignment and multiple events.	28
8.1.9	Object instantiation.	28
8.2	Typecasting	29
8.3	The <code>#include</code> pre-directive.	30
9	Debug	30
9.1	Duplicate switch...case conditions	31

*‘Words are not only tools to convey the thought,
they are mainly conditions for thinking’*

Martin Heidegger (1889—1976)

1 Introduction

Javascript first appeared in the mid 1990s and has since become one of the most widely used programming languages for front-end services of Web applications, at both small and large scale projects. The increasing popularity of Javascript has propelled it to the forefront of front-end services at any scale. In line with the

growing ambitions shown by recent systemic applications, the original Javascript requires some enhancements in order to meet a broader range of demands. The development of Typescript demonstrated that there are strong motivations and consistent margins for the implementation of new patterns that are further presented and pertain to areas that the original Javascript has not yet covered. We presented some new ideas for the promotion of new coding paradigms, inherent to advanced Object Oriented Programming (OOP) or the ‘*code event response*’, based on our vision of code as a timeline. Furthermore, the ability of ‘*speaking in Javascript*’ to develop custom dialects in order to lower the entry level to code writing, especially for beginners. These new features have been implemented into the transpiler OBJS.¹

2 Disclaimer

This paper is not intended to be an handbook of commands. The primary goal is to illustrate the underlying paradigms. The audience is not expected to be familiar with Javascript, but rather to understand the fundamentals of coding.

3 A note about this project

This transpiler project has been developed in Javascript and it is currently running as a demo version² at the time we are writing, as only formal parsing is performed: the (desired) full functionalities cannot be granted, because Javascript does not feature a sophisticated and granular memory management. For example, object typification could not be fully resolved if depending on the evaluation of decisions at runtime:

```
complex a = (1,2), b = (2,1);
var c = 1, d = 2;

var _rnd = Math.random();
var _ret = _rnd < 0.5 ? a + b : c + d;
var _prod = _ret * 2;
```

While the formal approach allows to determine the correct behavior of the operator ‘+’ in terms of arguments datatype (row 5), it could not be decided whether `_ret` (row 5) represents the sum of two `Numbers` or of `complex` objects: in fact, the choice depends upon the joint combination of the runtime value of `_rnd` (row 4) with inequality `_rnd < 0.5` (row 5), ultimately affecting the overload of the operator ‘*’ (row 6).

This transpiler project would like to be implemented in a single language, or the individual features should be incorporated into a Javascript engine.

¹The acronym of ‘Object JavaScript’.

²<http://alessandrorosa.altervista.org/objs/>

4 New and revisited syntax patterns

4.1 Multiple actions

The abstract pattern of ‘multiple actions’ is `<objects><op><values>` and it extends the action of the abstract binary operator `<op>`, by picking left and right values and dissecting the original pattern into a series of the simpler `<object><op><value>`, by means of two indexed sequences of objects. According to the number of right values, the relations, involved by this pattern, could show up as *one-to-many* or *many-to-many*.

4.1.1 Assignments.

Let the token `<op>` be the standard assignment operator ‘=’, in order to assign values to multiple variables. So the usage of this binary operator extends, thanks to this pattern, the standard destructuration. The multiple action here works in a *one-to-many* fashion:

```
var obj0 = "str";
var (obj1, obj2, obj3) = obj0;
console.log( obj0, ">>", obj1, obj2, obj3 );
```

Or let this assignment in *many-to-many* fashion:

```
var (obj1, obj2) = (1, 2);
console.log( obj1, obj2 );
```

Here a simpler but nifty example. Suppose we need an array with subsets of elements with a same value, according to a given law, here, the identity of the index `_i`, for sake of simplicity:

```
var _arr = [], _limit = 2;
for( var _i = 0 ; _i < _limit ; _i++ )
{
    ( _arr[_i*_limit], _arr[_i*_limit+1], _arr[_i*_limit+2] ) = _i ;
}
console.log( _arr );
```

We will get an array with nine entries, distributed as follows: `[0,0,0,1,1,1,2,2,2]`. This operator performs multiple assignments and works on the index that lists the appearance of each element on the left. The index management allows to work with the concept of wildcard: the code below includes the *asterisk* token on the right, which encodes a special assignment behavior: when the number of values on the left is greater than the ones on the right.

```
var (obj1, obj2, obj3, obj4) = (1, 2, *);
console.log( obj1, obj2, obj3, obj4 );
```

The value appearing immediately before the asterisk is assumed for filling the rest of the left objects whose index places do not match the ones of the elements on the right. In the above example, values will be assigned as follows: 1 and 2 to `obj1` and `obj2` respectively; 2 to `obj3` and to `obj4`. Not only basic datatypes can be assigned; for example, the return value of the function `doSomething` too:

```
function doSomething(a) {return a;}

var (obj1, obj2) = (1, doSomething(1));
console.log(obj2);
```

Or the contents of the function object itself:

```
function doSomething(a) {return a;}

var (obj1, obj2) = (1, doSomething);
console.log( obj2 );
```

The assignment operation requires that the left containers would be eligible to be filled with new values. This may not always be the case in the following examples including *not eligible containers*:

```
(obj1, 1+2) = (1,2) // no formulas allowed on the left
(obj1, 1) = (1,2) // no explicit constant values
(obj1, var) = (1,2) // no reserved words
(obj1, 'string') = (1,2) // no strings
(obj1, _obj2.method) = (1,2) // no method objects
(obj1, doNothing(1)) = (1,2); // no function calls

const _a = 1;
(obj1, _a) = (1,2) // no constant variables

function doNothing() {}
(obj1, doNothing) = (1,2); //no functions allowed
```

4.1.2 Comparisons.

This new pattern, in the basic assignment usage, may resemble a slight evolution of the standard destructuring syntax. We will show the new opportunities that arise when a new operator comes into play. We changed the abstract token `<op>` to the loose comparison operator `'=='`. This code in the `if` condition

```
if ( obj1 == 0 && obj2 == 1 && obj3 == 2 )
{
    do_something();
}
```

can be crammed into this more compact version:

```
if ( ( obj1, obj2, obj3 ) == ( 0, 1, 2 ) )
{
    do_something();
}
```

The new presentation appears to be a clearer version of the same instructions: all objects that play the same role are grouped and separated on the same side, reducing symbolic redundancy and the difficulty of reading a chain of different symbols with different precedence, as shown above with '&&' (logic and) and '==' (non-strict comparison).

4.2 Array

We will show below the patterns for special operations with arrays:

4.2.1 Special extraction.

The following in line aim at extracting elements from the original array according to the index range, which could consist of singletons (each referring to one element only) or with different (well-ordered) ends.

```
var _a = [9,8,7,6,5,4,3,2,1,0];
var _a1 = _a[6:5:0:1]; // ':' only the input indexes
var _a2 = _a[3-->]; // '-->' from index 3 (included) to the end
var _a3 = _a[<--5]; // '<--' from index 0 to 5 (included)
var _a4 = _a[3>--<5]; // '>--<' from index 3 to 5 (both ends)
var _a5 = _a[2<-->7]; // '<-->' from begin to index 3 and from 5 to end (indexes included)

console.log(_a1);
console.log(_a2);
console.log(_a3);
console.log(_a4);
console.log(_a5);
```

4.2.2 Pushing an element once or repeatedly.

When the token '[' (opening and closing square brackets) is appended to the identifier of an **Array** datatype then it turns into an operator that pushes (i.e., it appends to the end of the array) one or more elements inside it. We pushed only one element here below:

```
var _a = [0];
_a[] = 2 ;
console.log( _a );
```

This pushing operator '[' can be run multiple times in succession when appearing in combination with the asterisk operator '*', counting the value on the right, the container '_i' here :

```
var _a = [0], _i = 10;
_a[] * _i = 2 ;
console.log( _a );
```

The array ‘_a’ is filled in below with integer values ranging from 0 to 9:

```
var _a = [];
for( var _i = 0 ; _i < 10; _i++ ) _a[] = _i ;
console.log( _a );
```

4.2.3 Popping one element once or repeatedly.

The concepts behind the previous subsection can be borrowed from the popping (i.e., removing from the end of the array) operator ‘] [’ (closing and opening square brackets). In this case, however the pattern is simpler, because there is no input value to append.

```
var _a = [0,1,2,3];
_a[] ;
console.log( _a );
```

The following code pops out all elements from the array _a:

```
var _a = [0,1,2,3];
_a[] * 4 ;
console.log( _a );
```

4.3 JSON structures

JSON is the acronym of JavaScript Object Notation, a data structure embraced by curly parentheses and formally representing a collection of commas-separated entries. Each entry consists of three entities: from the left, (1) the referencing identifier i.e. the ‘key’, (2) followed by the *punctuator* ‘:’ in the middle and (3) the ‘object’ on the right:

```
{
  <key1> : <object1>,
  ...,
  <keyN> : <objectN>
}
```

If the right object <objectN> is of JSON datatype, the implementation shows up in this nesting fashion:

```
var _main_j = {
  <key1> : {
    <subkey1> : <object1>
  }
}
```


4.3.1 Compact and dynamics construction

The implementation of JSON objects in Javascript can be achieved by *explicitly* declaring the constituents, according to the above code. JSON objects can be *dynamically* populated, but not created in this manner unless they are regarded as associative arrays. We overloaded the symbol ‘:’ to act like a binary operator that takes two input **Arrays**, including the keys and values, appearing on the left and on the right respectively. Elements with the same index are paired to form a new JSON object. In the example below, the operator takes two input *explicit* arrays:³

```
var _a = [a,b,c]:[1,2,3];
console.log(_a);
```

Furthermore, two *implicit* **Array** objects have been input below:⁴

```
var keys = [1,2,3], values = [a,b,c];
var _j = keys : values;
```

This latter declination was not implemented yet, because of the restrictions we illustrated in the ‘Disclaimer’ section 2.

4.3.2 Decorated tokens for JSON.

A nested JSON structure implementation is essentially a multi-branched tree with *node distance* metric.⁵ Each node has a *depth level*, which is an integer set to 0 for the JSON object at the *root* of the tree and increasing by one unit as JSONObjects are nested in each other. The tree transversions from parent to child nodes and back can be represented visually in the downward and upward directions respectively. If the metric is *oriented*,⁶ the tree transversion returns an integer that ranks the node’s depth; otherwise, if the metric is *absolute* (not-oriented), one rates the path length, i.e. the number of steps required to traverse the tree from some start node to the destination. The *parental distance* is computed in terms of oriented metric and it applies to the ascending direction only.

Remark 1 *The goal is to develop tools that could improve the interaction between nested JSON objects.*

Let the general concept of *decorated token*, an alphanumeric reserved identifier that is formally prefixed by the symbol ‘@’ (⁷) and conventionally playing as an alias for

³A list of comma-separated objects is included between an opening and a closing square bracket.

⁴An explicit array that is referred by one identifier.

⁵Defined ‘**immediate**’ for short.

⁶The ascending and descending transversion is denoted by the positive (‘+’) and negative (‘-’) operator respectively.

⁷Non-conformal to the standard naming convention.

objects with different roles, depending on the syntax pattern where the decoration is applied. The decorated tokens `@parent` and `@root` have been designed to refer to JSON objects of constant parental distance, that is, 1 and the node depth respectively. Target nodes can be reached by parental direction only: multi-branched tree transversion is not an invertible operation,⁸ so the exact starting child node after ascending to its parent cannot be determined, unless the latter has one only child. Let the next example, featuring two nested levels and the `@parent` decorated token:

```
var _j1 = {
  a : 1,
  sub_j : {
    fn1 : function(){ return @parent.a; },
    fn2 : function(){ return @parent(2).a; }
  }
}

alert( _j.sub_j.fn1() );
```

Multiple nodes ascension is calculated iteratively using a single input number, whose default value is 1. Then `@parent(2)` would *tentatively* point to the JSON object at two levels up;⁹ the transpiler will throw an error, because this decorated token does not resolve into a valid object. This is not the case for the token `@parent`,¹⁰ that refers to `_j1`. Now let

```
var _j1 = {
  a : 1, b : 2,
  j2 : {
    j3_1 : {
      fn() : function(){ return @root.a },
      str : 's'
    },
    j3_2 : {
      fn() : function(){ return @parent.j3_1.str }
    }
  }
}

alert( _j3.fn() );
```

Regardless of the original depth level of the calling structure, the decorated token `@root` goes straight, in one only instruction, to the JSON object `_j1` at top of the tree. This initial implementation not only allows to refer to parent nodes, but also

⁸While moving downwards to a child keeps track of the starting node, moving upwards to the parent loses this information.

⁹At present, the formal parsing does not allow to parameterize the multiplier: for example, to input one variable: `@parent(n)`.

¹⁰Or simply `@parent`.

opens to composition and suggests the possibility of quickly accessing to *sibling nodes*:¹¹ for example, the path `@parent.j3_1.str` in the above code.

4.4 Reverse self-operators

The standard self-operator syntax pattern `<id#1><op><assignment><id#2>` expands as follows: `<id#1><assignment><id#1><op><id#2>`.

The binary operator `<op>` is assumed to take on the two input parameters `<id#1>`, `<id#2>`; it sets the result to the variable `<id#1>`. The direction of the operator is left-to-right, from `id#1` to `<id#2>` and it finally goes back again to `<id#1>`.

We also have the chance of diverting the result to `<id#2>`. This is possible through the reverse self-operator syntax pattern. This implementation would not make sense for sets of commutative values¹², say the addition operator for real numbers. So we invite the reader to consider `Strings` instead: a common, non-commutative¹³ datatype. In the following example, let some `Strings` appended to each other; the reverse syntax pattern formally swaps the operator symbols inside the old one. Here we used the notation `+=`, which reverses the standard operator `+` and sets the result to the container `<id#2>`:

```
var _s1 = 'I', _s2 = 'am';
var _s3 = _s1;
_s3 += _s2;
@factotum.log(_s3);

_s3 = _s1; _s3 += _s2;
@factotum.log(_s3);
```

4.5 The ifchain decisional statement

The relationships governing the interaction of multiple conditions might be of dependency or not. In the first case, conditions are resolved *in logical order*: a common practice in *defensive programming*; they could be assumed to belong to a chain of nested `'if'` statements. If no code is required between the tests of the conditions, they all can be represented into this compact version, announced by the reserved instruction `'ifchain'`:

```
ifchain ( obj_exists( _obj ), is_of_type( _obj ) )
  do_something();
else ifchain ( obj_exists( _obj2 ), has_the_property( _obj, 'prop' ) )
  do_something_else();
```

¹¹Standing at the same level and sharing the same parent node.

¹²Roughly speaking, when `<id#1><op><id#2><assignment><id#2><op><id#1>`

¹³For the binary operator `'+'`.

Multiple conditions are embraced between round parentheses.¹⁴ For sake of clarity, the above code has been expanded as follows:

```
if ( obj_exists( _obj ) )
{
    if ( is_of_type( _obj ) )
    {
        do_something();
    }
}
else if ( obj_exists( _obj2 ) )
{
    if ( has_the_property( _obj, 'prop' ) )
    {
        do_something_else();
    }
}
```

This pattern gathers conditions – normally piled up into nested blocks like the above expansion – into a simple list.

4.6 Extended switch

We add the possibility of entering POSIX regular expressions into the `case` conditions of the `switch` statement, in order to test full classes of values, rather than single elements, such as numbers or strings:

```
var _a = 1;
switch( _a )
{
    case /^[0-9]+$/:
        console.log( 'integer' );
        break;
    case /^[0-9]+[\.]?[0-9]+$/:
        console.log( 'decimal' );
        break;
    default:
        console.log( 'unknown' );
        break;
}
```

We used regular expressions to generate different responses, whether the variable `_a` is an integer or a decimal number.

4.7 Fork operator

The ternary operator `?` provides a compact and comfortable syntax pattern that squeezes the `if` and can be implemented within larger expressions. In any case, the return value can only be set to one variable per call. The ‘fork’ operator `|<`

¹⁴This pattern is illegal in ordinary Javascript.

aims at overcoming such a structural restriction. The basic pattern is very similar to the ternary version, in which the colon operator ':' separates the tokens, but it accepts three parameters:

```
<condition> |< <id#1> : <id#2> : <value>
```

The target container for <value> would be id#1 or id#2 if the <condition> holds or not respectively:

```
var a = 0, b = 0, c = 3;

c > 2 |< a : b : 4;

console.log( "c", c, "a", a, "b", b );
```

The value 4 will be expected to be set to a, whereas b will be left to the original value 0. The fork operator could also accept four parameters at most:

```
<condition> |< <id#1> : <id#2> : <value#1> : <value#2>
```

In practice, let the code

```
var a = 0, b = 0, c = 3;

c < 2 |< a : b : 4 : 5;

console.log( "c", c, "a", a, "b", b );
```

The first two are destination variable identifiers (a, b) again, but the last couple (4, 5) to the objects that will be set to the variables *respectively*: then a=4 if c < 2 holds, and a=5 otherwise.

4.8 Binary operators

OBJS implements the following binary operators for the evaluation of values and the return of the left or right parameter whether the far left condition holds or not respectively, i.e. according to the following pattern:

```
\texttt{<return-value><assignment><left-par><op><right-par>}
```

or, concisely.

```
\texttt{var a = b <op> c}
```

<i>Operator</i>	<i>Definition</i>	<i>Condition</i>
??	Null coalescing	b is not <code>null</code>
?:	Elvis operator	b is not false or 0
?:	Safe navigation	b is <code>null</code>
?==	loose equality	b and c are equal in value only
?===	strict equality	b and c are equal in value and type
?<	lesser	b < c
?>	greater	b < c
?<=	lesser and equal	b <= c
?>=	greater and equal	b >= c

4.9 Decorated identifiers

The entries in the table below are not part of Javascript standards. Decorated identifiers are implemented for OBJS internal usage exclusively. They are prefixed by the symbol ‘texttt’ and applied in different contexts; as long as we need them, we will run into their details.

Identifier	Purpose
1, 2, ...	reference to arguments inside <code>#overload</code> headers
<code>arg</code>	applied inside the ‘argument safe’ syntax pattern
<code>counter</code>	applied to some special syntax patterns
<code>file</code>	retrieves the file name where the running code belongs to
<code>line</code> , <code>column</code>	coordinates of this token inside the text code
<code>namespace</code>	retrieves the namespace in use
<code>parent</code> , <code>root</code>	applied to nested JSON structures
<code>src</code>	reference to source object inside <code>#overload</code> <code>typecasting</code> header

4.10 Namespaces

Inspired by accidents that may occur during the development of large back-end projects in PHP, we implemented *namespaces* for Javascript, because front-end services are also becoming increasingly large and demanding.¹⁵

Namespaces are logical domains, where identifiers are re-organized under specific naming conventions, to prevent collisions between homonymous objects, possibly declared elsewhere. That convention shows close syntax similarities with the

¹⁵The `use strict` directive in Javascript prevents to refer to undeclared variables. PHP and Javascript do not feature a rigid liveness analysis, for tracking multiple declarations of the same variable within the same scope for example.

path pattern of filesystems,¹⁶ where unique referrers are also required.

```
namespace ns1
var _a1 = 1;
exit namespace

var _f = 1 + 2 / 3;
alert( _f );
alert( ns1\_a1 );
```

When isolated, the reserved word `namespace` automatically closes the previous domain, if any, and it opens a new one. On the contrary, `exit namespace` forcibly closes the current domain:

```
namespace ns1
var _a1 = 1;

namespace ns2
var _a1 = 2;

exit namespace

alert( ns1\_a1 );
alert( ns2\_a1 );
```

Namespace domains can be embraced by curly parentheses, for sake of clarity about their contents:

```
namespace ns1 {
    var _a = 1, _b = 2;
    function fn(x){ return x + 1; }
}

namespace ns2 {
    var _a = 3, _b = 4;
}

var _c = 0; //everything out does not belong to namespaces
console.log( ns1\_a, ns1\_b );
console.log( ns2\_a, ns2\_b, _c );
```

If namespace paths are too long, the reserved term ‘`as`’ may help to set up shorter aliases:¹⁷

```
namespace \lev1\lev2\lev3;
var _a = 1;

use \lev1\lev2\lev3 as short3;
console.log( short3\_a );
```

¹⁶Particularly, of Unix-like systems.

¹⁷There exists a minor risk of falling back again into collisions between aliases anyway.

Namespaces could also include `class` declarations:

```
namespace \lev1\lev2\lev3
class cls{
    constructor(){ /* do nothing */ }
}
exit namespace

var _c = new \lev1\lev2\lev3\cls;
```

5 Data typification

5.1 Typified declarations

In order to introduce this feature and to compare this new syntax pattern with the standard Javascript implementations, we first reported some code samples, paired in lines, where each new syntax pattern, including abstract `<tokens>`, precedes the related ordinary version:

```
<datatype> <referrer>; // declaration without arguments
var <referrer> = new <datatype>();

<datatype> <referrer> = _arg; // single argument
var <referrer> = new <datatype>(_arg);

// multiple declarations
<datatype> <referrer#1>, <referrer#2>;
var <referrer#1> = new <datatype>(), <referrer#2> = new <datatype>();

// multiple arguments
<datatype> <referrer> = (_arg1,_arg2);
var <referrer> = new <datatype>(_arg1,_arg2);
```

When there are more than one parameter, they are embraced between round parentheses:

```
complex _imag = ( 0, 1 );
```

This typified declaration shows flexibility by supporting nested constructions and multiple declarations:¹⁸

```
complex _a = ( int _real = 1, int _imag = 0 ), _b = ( complex (1,2) );
```

In the next example, we declared an object of `complex` datatype and we multiplied it by 2, and we finally added the resulting product to 1:

¹⁸In order to let this pattern deal with the standard `var/let` declaration, we followed this policy: (1) to use `let` only inside function and statement bodies and (2) `var` outside, that is, in the main code thread.


```
complex _a = 1.1;
@factotum.alert( _a * 2 + 1 );
```

Although it is redundant in terms of operators precedence, we will edit the formula once more, this time putting the round parentheses around the product, $(_a*2)+1$, to make computations more understandable: the above formula first multiplies a `complex` object by a `Number` object; finally, the returned `complex` product adds to a `Number`. The object `_a` is of non-standard `complex` datatype, so $_a*2+1$ requires the translation into this chain of method calls:

```
complex _a = 1.1;
@factotum.alert(_a.mul(2).add(1));
```

As we change the above formula into $_a+1*2$, where 1 and 2 are (standard) `Number` objects,¹⁹ a new translation will be required:

```
complex _a = 1.1;
@factotum.alert( _a.add( 1 * 2 ) );
```

Remark 2 *The operators overloading could represent an efficacious alternative to method calls, being impracticable to work out formulas with increasing level of complication.*

5.2 Functions in Javascript

Functions are *finite, sequential aggregations of statements*, assembled in accordance with the traditional I/O model: when input objects (the arguments) are fed into the function, it may optionally `return` one value or not, before it terminating its run.²⁰ The function represents a facilitation to run several commands after only one call; it could set up a *one-to-one* or *one-to-many* relation from the (one) call to (one or many) statements therein. Functions are of *modular nature*, as their design is based on a single block of reusable code that is separated from the main code thread.

5.2.1 A short synopsis on the declaration pattern

This is the abstract, formal pattern to declare functions in Javascript:

```
<function-header>
{
  <function-body>
}
```

¹⁹The star operator ‘*’ follows the default implementation and it has not need to be overloaded.

²⁰Javascript treats functions as datatypes, with the ability of instantiating them as new objects with members and `prototyped` methods.

The abstract `<function-header>` expands into the `header` at the top and the following `body` of statements:

```
function <name>( <arg-id#1>, ... )
{
  // all statements are optional: body could be empty
  <statement#1>
  <statement#2>
  ...
  <return-statement>
}
```

The token `<name>` refers to the function identifier, for the next calls.²¹ Function calls execute statement(s) within its body in the same order as they appear throughout the code; the last statement could optionally include the reserved word `<return>`, in order to send an object to the main code thread.²² Therefore it makes sense to implement datatype specification into function declaration.

5.2.2 Typified function declaration

As we did for typified variables, we are going to typify function declaration too: both have similar declarative patterns. We add two new specifications, inherent to the new datatypes mentioned and collectively classified as *function typification*. The abstract token `<return-datatype>` refers to the datatype returned by the function call, whereas `<arg-datatype#n>` points to the datatype of each input argument `<arg-id#n>` between round parentheses:

```
<return-datatype> function <name>( <arg-datatype#1><arg-id#1>, ... )
{
  <function-body>
}
```

This pattern can be implemented in *weak* or in the *strong* version. We first present two examples of *weak function typification*. The weak character is due to the omission of the `<return-datatype>`, which is assumed as a generic `Object` by default. We declared below two homonymous functions ‘fn’ featuring different typifications: the first takes only one input parameter of `complex` datatype, whereas the second declaration takes only one `Number` datatype

²¹This token is not mandatory: if omitted, functions are assumed as *anonymous*. But just apparently at users scope, as the Javascript engine would apply a referrer to record the function into memory at a deeper level.

²²The `<return>` token is not mandatory. Given the `return` and the `object` token inside the function body, three cases may occur: (1) both tokens are given, (`return object`): the function sends the variable `object` to the calling code; (2) only the `return` token (`return ;`) which actually returns no object, (3) none of the two tokens, in order to not perform any return action at all.

```
function fn(complex a){ return "complex"; }
function fn(Number a){ return "number"; }

console.log( fn( 1 ) );
console.log( fn( new complex(1,2) ) );
console.log( fn( "String" ) );
```

All declarations of homonymous objects are overridden by the last in line. OBJS uses the arguments datatype to recognize the exact typified declaration and then to mangle it. The *mangling technique* allows the registration of multiple typified declarations of a same homonymous function, in order to find the exact match for the requested typification. A warning would be thrown if the call finds no match at run-time. For example, the simple call `fn("String")` at row 6 would throw a warning because no function that takes one only `String` argument has been registered. This advanced example combines weak typification and formulas:

```
function fn(complex c){ return c; }

complex c1 = (1,2);
var _sum = c1 + fn( new complex(1,2) );
```

In the economy of this transpiler, the weak typification breaks the chain of formal datatype recognition: while the left addend `c1` is correctly detected as of `complex` datatype, the addend on the right, resulting from this preventive extraction

```
var _o_1 = fn( new complex(1,2) );
var _sum = c1 + _o_1;
```

is assumed as of generic `Object` datatype. The generic datatype can be viewed as a failure along the datatype recognition process, like an ‘indetermination status’ propagating to subsequent values that depend on the call to `fn`; thus the variable `_sum` would be a `Object` too in the cascade fashion. The solution is to use the ‘*strong function typification*’, a more performant pattern that includes the `return-datatype` in the function header ⁽²³⁾ on the left of the `function` token:

```
complex function fn(complex c){ return c; }

complex c1 = (1,2);
var _sum = c1 + fn( new complex(1,2) );
```

The formal datatype recognition chain cannot be broken now. The token `<return-datatype>` fills the gap left by the weaker pattern and serves the same purpose as in the typified declaration. Thus the variable `_sum` includes the value resulting from the action induced by the operator ‘+’, which takes two `complex` objects.

²³The `return` is mandatory here.

Remark 3 *Weak and strong function typifications coexist for granting full compatibility between standard and OBJS patterns.*

Both typifications can be extended to the *arrow function* pattern:

```
//weak typification
var fn = (complex a, complex b) => a * b;

//strong typification
complex fn = (complex a, complex b) => a * b;
```

With the necessary adaptations, the strong typification can be exported from functions to methods within JSON structures:

```
var _j = {
  Number fn : function( Number a ){ return a; },
  complex fn : function( complex a ){ return a; }
}

var _c = _j.fn(new complex(1,2));
var _doubled = _c * 2;
@factotum.alert( _doubled );
```

Or to the declarations of **prototyped** members:

```
//Javascript functions are also intended as datatypes
function obj(){

obj.prototype.method = complex function( complex c ){
  console.log( "complex", c );
  return c;
}

obj.prototype.method = function( o ){
  console.log( "object", o );
  return o;
}

var _obj = new obj();
_obj.method( new complex(1,2) );
_obj.method( 1 );
```

As well as to **class** methods:

```
class cls{
  constructor(){
    complex fn(complex c){return c;}
    Number fn(Number n){return n;}
    //String fn(String str){return str;}
  }

var _obj = new cls();
var _n = _obj.fn( 1 );
```

```
var _c = _obj.fn( new complex(1,2) );
var _str = _obj.fn( "a" );
@factotum.alert(_c); @factotum.alert(_n);
@factotum.alert(_str);
```

The above code throws a warning: the `String` typed version of the `fn` method was called, but not declared yet (here commented). As line 5 is un-commented, the newly compiled code will be able to find the exact match.

5.2.3 Safe argument

The purpose of this syntax pattern is to ensure that function arguments are of the specified datatype. If no such match is found, the argument is typecasted to the class itself (provided that the conversion has been encoded). This pattern applies to input arguments inside the function header only. The argument identifier must be prefixed by the symbol `‘` and preceded by the datatype identifier. It applies to weak and strong typification of functions.

```
function fn( complex @arg ) { return arg; }
```

6 Syntactic sugars

We reported below two ‘syntactic sugars’ that may help avoid long codes.

6.1 Block repeater

This simple pattern could avoid long `for` loop headers, as it ‘multiplies’ the block of instructions:

```
4 * {
    console.log( @counter );
}
```

This special environment re-parses into the ordinary `for`-loop. The internal decorated identifier `counter` works to build up the ordinary code and keeps track of the loop counter increment.

6.2 Ordered sequences.

This syntax pattern returns an array of values ranging from end to end immediately:

```
var _a = (1,...,10);
console(_a);
```

This pattern can be applied to alphabetic sequences:

```
var _a = ("a",...,"z");
console(_a);
```

Similarly to C⁺⁺, it is possible to simulate the call-by-reference syntax, as follows:

```
function fn( Number & v ){ v++; }

var a = 1;
fn( a );
console.log( a );
```

The value of variable `a` is expected to store the value 2.

7 Optimizations

We browse some optimization strategies to lessen the code; they are elaborated when the transpiler `pragma optimize` mode is set on.

7.1 Unreferenced function argument

The next example shows a function declaration including two parameters `a` and `b`; only `a` is referenced within the body, so `b` can be safely removed and lessen the arguments stack.

```
function fn( complex a, complex b ) {
    return a;
}
```

7.2 Unreachable or dead code

We provided some examples including code which will not be run for different reasons. Below, no line of code will be run after the `return` statement; thus it can be dropped out:

```
function fn( complex a, complex b ) {
    return a+b;
    a /= b;
}
```

Blocks of code subdued to the evaluation of condition statement will not be run if the latter evaluates to 0, `false`, `null` or `undefined`; here again, the (block of) code can be safely dropped out:

```
var a = 1, b = 0 ;

if ( a && b ) { doSomething(); }
```

7.3 Isolated deletion

Those identifiers that are only referenced will be assumed to be irrelevant throughout the run and will be removed:

```
function fn( complex a, complex b ) {  
    return a;  
}
```

7.4 Constant folding

The result of arithmetic expression, including constant values only, will be automatically calculated and will replace the formula:

```
var _a = 1 + 2 / 4;  
//this line is replaced by : var _a = 1.5;
```

7.5 Constant propagation

The constant 1, assigned to `_a` is ‘propagated’, i.e. the identifier is replaced with the same value:

```
var _a = 1;  
var _b = _a;  
  
/* the code is optimized to  
var _a = 1;  
var _b = 1;  
*/
```

Constant folding and propagation techniques can be jointly applied, like in the case below, where the numerical expression is elaborated and the result is propagated to the subsequent occurrences of `_a`:

```
var _a = 1 + 5;  
var _b = _a ;  
  
/* the code is optimized to  
var _a = 1;  
var _b = 1;  
*/
```

8 Preprocessors

8.1 The `#overload` directive.

Overloading represents *the ability of customizing syntax patterns by binding them to some block of code*. Developer should not read such a ‘personalization’ as a threat

for the concepts defragmentation, or as a super-structure, like a new language within the official language:

Remark 4 *Overloading does not pertain to new procedures because it is a portable artifice for coding the same actions more efficiently by replacing them with easier-to-read patterns.*

Like the function declaration, the overloading process consists of three stages: (a) *registration* of settings (like declaration) and (b) *recognition* of the overloaded pattern: the operator and the arguments datatypes (like the function call); (c) the *application* to ordinary code. Overloading must be declared outside the compound statements (function declarations, loops, decisions, ...), and preferably before the main code thread.

OBJS implements the multi-purposed `#overload` directive that includes some patterns depending on the candidate object to be overloaded: possibly, an (1) operator, (2) function, (3) reserved word, (4) event, (5) typecasting.²⁴

8.1.1 Symbolic operators

Let a ‘*symbolic operator*’ be any typeset character which is not alphanumeric or one of these punctuators: comma, full stop, parentheses, quotes, semicolon and tract. Operator overloading relies on datatype typification (§5.1) and it can be properly listed among the translation activities, strictly speaking. Overloading applies to symbolic operators of unary or binary family only, that is, those taking one or two input arguments. Like the function declaration, the abstract syntax pattern consists of parameters and settings in the top **header** and of a **body** of instructions:

```
#overload <associativity> <self> <priority> <role>
  <return-datatype> <symbolic-operator>
  ( <input-arguments> )
{
  <body-with-statements>
}
```

The variety of parameters in this **header** offers a sufficient degree of freedom to customize the operator behavior. The basic set of mandatory parameters includes the tokens `<return-datatype>` and `<symbol>`. Other parameters are apparently optional as they are not required *if overloading does not need to be sharply customized*. For instance, the parameter `<self>` would be optional by default, but it is required in order to register self-operators, such as ‘+=’.²⁵ The parameter

²⁴Overloading is part of so called *extensible languages*, which include tools to modify the semantics of patterns and operators [1, p. 58].

²⁵Or also ‘-=’ for the reversed, non-commutative version. Self-operators are assumed to be binary and to ‘compress’ the usual formulation: the return value is assigned to the same left argument.

`<role>` is optional, but required to set up custom precedence during the evaluation of expressions; operators precedence is just a convention that we may change arbitrarily, with regard to the datatypes involved. When optional parameters are omitted, the transpiler attempts to recognize them, according to default settings and to the operator symbols.

We are now able to overload two versions of the same symbolic operator, now endowed with distinct associativity: either left-to-right (LR, ‘`prefix`’) or right-to-left (RL, ‘`postfix`’). Then we overloaded twice this unary operator ‘!’ to take an argument of `complex` datatype:²⁶

```
#overload prefix operator complex !(complex @1){ return new complex(0,
@1.imag); }

#overload postfix operator complex !(complex @1){ return new complex(@1.real,
0); }

complex _z = (1,1); // new feature: typed declaration

@factotum.alert(_z!); @factotum.alert(!_z);
```

The semantics of the symbol ‘!’ have not been associated to the usual `logical not` operator: *operators overloading is not restricted to preset semantics and symbolic definitions*. In the next example, we picked up a sequence of arbitrary characters ‘!!!’ and registered it as a custom binary operator that takes two input integers (²⁷) and returning an `Array` object, filled by the ordered sequence of values ranging between the ones set into the two decorated parameters:

```
#overload operator Array !!! (Number @1, Number @2) {
  let _a = [];
  for( let _i = @1; _i <= @2; _i++ )
    _a.push(_i);
  return _a;
}

alert( 1 !!! 10 );
```

OBJS can also to customize ‘*polyadic*’ operators which are not symbolic and take a larger number of input arguments.

```
#overload polyadic Boolean (Number @1) among (Number @2, Number @3) { return
(@2 <= @1) && (@1 <= @3); } alert( 5 among( 1, 2 ) );
```

8.1.2 Functions

Function identifiers can be overloaded by different comma-separated aliases. In the next example, the method `tg`, belonging to the custom class `complex` and evaluating the trigonometric tangent function (accepting one input value of `complex`

²⁶The identifier `@factotum` refers to an object included in the OBJS environment.

²⁷Encoded by the decorated tokens ‘@1’ and ‘@2’.

datatype), has been overloaded for being called through `tan` and `tang`. In opposite to the present example, this overloading could be useful to differ homonymous methods that belong to different class definitions. Notice that it is essential to input argument datatype(s), in order to recognize the original function call pattern.

```
#overload function complex tg alias tanX, tangX(complex @1){
    return @1.tg();
}

complex _z = (1,0);

var _t1 = tg(_z); // custom defined to work with complexes

var _t2 = tanX(_z); var _t3 = tangX(_z);

@factotum.alert( _t1 + _t2 + _t3 );
```

The function `tg` has been already registered in the default settings and the above overload will just add the new aliases

8.1.3 Commands

The overloading of ‘`command`’ reworks the essentials of the operator concept, as it is transposed to the naming convention acknowledging alphabetic characters only. The first argument datatype was set to ‘`generic`’, a fictional datatype meant as an OBJScoding convention to accept input parameters of any given datatype, for the overload recognition pattern to work in any circumstance.

```
#overload command boolean is(generic @1, String @2) { return RegExp( @2, "i"
).test( typeof @1 ); }

console.log( 2 is "complex" ); console.log( "hello" is "string" );
```

In the next similar case, we overloaded a command that check the existence of an element inside the input array.

```
#overload command boolean inside(generic @1, Array @2) { return
@2.includes(@1); }

console.log( 1 inside [1,2,3] );
```

8.1.4 Overloading the reserved: speaking in Javascript

This side feature customizes the official reserved words in order to have a version closer to human language: it could be beneficial to beginners (especially, younger ones), or to people liking Javascript code to be declined into their native languages.

```
//set language recognition to FR(French) only
#overload reserved LANG FR alors as DROPPABLE #overload reserved LANG FR si as
```

```
if #overload reserved LANG FR est as === #pragma translator FR
var _a = 1; si( _a est 1 ) alors alert( 'Bonjour' );
```

which pre-compile into the ordinary code:

```
var _a = 1; if ( _a === 1 ) alert ( 'Bonjour' );
```

The French term ‘alors’ (‘then’ in English) is redundant and not featured among the official Javascript specifics, so it will be dropped (set as **droppable**). The standard ISO 3166-1 alpha-2 convention was adopted for the language two-letters identifier. Strictly speaking, this is not about ‘overloading’ now, as this implementation more precisely concerns of ‘replacement’. We continued to use the same preprocessor for sake of simplicity.

This feature could be useful to customize the reserved words, for the code to look easy to be read, especially for practitioners or anyone else liking to read code in one’s own native language. Languages are referred according to the ISO 3166-1 alpha-2 coding convention.

```
#overload reserved LANG IT allora as DROPPABLE #overload reserved LANG IT é as
=== #overload reserved LANG IT se as if #pragma translator IT //set language
recognition to IT only
var _a = 1; se( _a é 1 ) allora alert( 'ciao' );
```

which pre-compile as follows:

```
var _a = 1; if ( _a === 1 ) {
    alert ( 'ciao' );
}
```

8.1.5 Code event response: overloading the events

Inspired by liveness analysis, we see code as a *living entity*. Not evidently endowed of self-consciousness, but of lifetime and being able to get inputs and to react to them: code is not just as a collection of actions, but something having its story of events that flow one after the other. Events can be tracked down and overloaded, like we did for operators. Specific code is triggered and run in response to the input events: for example, when a new element is pushed into an array, or a function is called.

8.1.6 Events timeline.

Event overloading can be registered for responses that are tracked *before* or *after* the events. The pattern `on_before_<event>` is called immediately before the event, whereas `on_<event>` runs after the event has occurred. For example, let the conventional term ‘decl’ refers to object declarations; the compositions ‘`on_before_decl`’

and `on_decl` bind to two events triggered before and after the declaration respectively. We overloaded these two events for the reserved token `'var'`.²⁸

```
#overload event on_before_decl to var
  { console.log('before_declaration'); }
#overload event on_decl to var
  { console.log('after_declaration'); }

var _a = 1;
```

Events overloading could be subjected to restrictions or not, according to the token value `<target-object>`:

```
#overload event <events-name> to <target-object>
  ( <input-arguments> )
{
  <body-with-statements>
}
```

The token `<target-object>` allows to register the event and to bind it to one or to multiple objects. For the registration of the family of events `decl`, the target could be a variable identifier or reserved words open to declaration: `'const'`, `'let'`, `'var'`.

This is the full list of overloadable events: *assignment*, *declaration*, *object instantiation* and *destruction*, *function* and *method call*, *pushing into* and *popping from one array*.²⁹

8.1.7 Array popping and pushing.

If elements are *pushed* into or *popped* from an array, the events `on_array_push` and `on_array_pop` will be triggered respectively. The array plays as the `<target-object>` required in the event registration. Here the digit 1, in the *decorated* variable `'@1'`, runs like an index to the first element of the 1-index based array of the target objects, announced by the reserved token `<to>`: thus `'@1'` stands for `'_a'` and `'@2'` for `'_b'`.

```
#overload event on_array_push to _a, _b
  { console.log(@1.length, @2.length); }

var _a = [];
for( var _i = 0; _i < 10; _i++ ) _a.push(1);

_b.push('string');
console.log( _a, _b );
```

²⁸ Alternatively, it could be applied to `'const'` or to `'let'` declaration.

²⁹ The abstract token `<event>` would be encoded by `assign`, `decl`, `new`, `delete`, `function_call`, `method_call`, `array_push` and `array_pop`.

8.1.8 Declaration, assignment and multiple events.

The events ‘on_decl’ (object declaration) and ‘on_assign’ (object assignment) have been overloaded for variables a and b:

```
#overload event on_decl, on_assign to a, b
  { console.log('response'); }

var a = 1, b = 2;
    a = 2, c = 4;
```

All declarations and assignments can be affected:

```
#overload event on_decl, on_assign to @all
  { console.log('triggered'); }

var a = 1, b = 2; // declarations
    a = 2; // assignment
```

When the token <target-object> in the declaration takes on the decorated value ‘@all’, the event registration extends to any object: in the code below, the string ‘triggered’ will be displayed when any object has been declared or when one value has been assigned:

8.1.9 Object instantiation.

The event ‘on_new’ is triggered when objects have been instantiated. The overload header includes the reserved token ‘to’: this specification announces that this event is triggered if the <target-object> is of complex datatype only:

```
#overload event on_new to complex
  { console.log('instantiation'); }

// typified declaration
complex _c1 = (1,2);
// standard declaration and instantiation
var _c2 = new complex(3,4);

var _s = _c1 + _c2;
var _n = new Number(1);
```

This code indicates that only two events on_new have been triggered: one after the explicit typified declaration complex _c1 and the second after the standard instantiation _c2 = new complex(3,4). No on_new event is triggered for the instantiation of the Number object because this datatype has not been mentioned in the event <header>.³⁰

³⁰But we could fix it by applying this code: #overload event on_new to complex, Number.

8.2 Typecasting

OBJS performs some liveness analysis to determine lifetime and properties of variables, as well as *typecasting*, defined as the *creation* (‘casting’) of a new object of class A *from* another object of class B. This process can be thought as a **datatype conversion**, carried out in two stages: (1) the *registration* of the handler for the conversion from source to destination datatype, (2) the *parsing* of the typecasting syntax pattern, in order to run the handler and activate the conversion, assuming that stage 1 has covered the input datatype.

Stage 1 can be completed using the traditional method `typecasting`, which can be implemented as a **prototype** or as a **class** member.³¹ Otherwise, typecasting can be registered as an overloading using this abstract syntax pattern:

```
1 #overload typecasting <source-datatype> to <destination-datatype>
2 {
3     <body-of-statements>
4 }
```

which manifests in this example:

```
1 #overload typecasting complex to segment
2 {
3     return new segment( 0, 0, @src.real, @src.imag );
4 }
```

The token `@src` is defined as *decorated token*, a standard feature in the OBJS environment: it is a class of internal objects, prefixed by ‘@’ and performing a variety of tasks depending on the context in which they appear. Regarding stage 2, the typecasting can appear *semantically* similar to the typed declaration (subsection 5.1), but the behavior is analogous to a left-to-right unary operator from an *operational* viewpoint, played here by the `complex` datatype that accepts one input argument on the right 1.1:

```
1 var _a = (complex)1.1;
2 @factotum.alert(_a*2);
```

Typecasting also features chained construction:

```
1 var _h = (quaternion)(complex)1.1;
2 @factotum.alert(_h*2);
```

Typecasting can be ‘implicitly’ used (i.e., without variable identifiers) and sequentially chained to return a field or call a method:

```
1 var _r = ( (complex)(1,2) ).real;
2 var _sin_i = sin( (complex)(1,2) );
```

³¹Depending on the nature of the container: `function` or `class` respectively.

8.3 The #include pre-directive.

This `#include` pre-directive embeds the contents of input files into the calling code, at the same entry line of the preprocessor, according to the pattern: `#include "<filepath>".` It can appear inside bodies of functions, of loops, of decisional statements, or of iterable data structures such as (`Array` or `JSONs`). The major benefit consists in not dealing with large chunks of code: smaller pieces are easier to be read, managed and possibly used again elsewhere:

```
class someclass {
    constructor (){}

    #include "members.js"
    #include "methods.js"
}
```

Both files are assumed to be save in the same folder as of the above code. Namely, the file `members.js` includes

```
var _m1 = "str", _m2 = 1;
```

and the contents of the `methods.js` are

```
my_method_1(){ return this._m1; }
my_method_2(){ return this._m2; }
```

In general, the `#include` pre-directive reads the contents of the files matching the following syntax patterns, also featuring wildcards:

```
//single file per call
#include "folders-path/filename"

//multiple files from the whole input folder
#include "folders-path/filename/"

//same pattern, but with wildcards variation
#include "folders-path/filename/*"

//all files in the folder, starting with the letter "g"
#include "folders-path/filename/g*"

//all files in the folder, ending with suffix ".js"
#include "folders-path/filename/*.js"
```

9 Debug

This section includes some features that are available only in debug mode, which requires a longer compile time than the standard run.

9.1 Duplicate switch...case conditions

If the `switch ... case` statement has been developed in a long span of time as well as it might possibly include a very long number of `cases` too, it may happen that a same case has been mentioned twice. The following feature detects whether such duplicates have occurred:

```
switch(a)
{
    case 1+1:
        doSomething();
    break;
    case 1+1:
        doSomethingElse();
    break;
}
```

References

- [1] Aho V.A., Ullman J.D., *The Theory of Parsing, Translation and Compiling*, Vol. I, Prentice Hall, 1972.